parent plate, d is the diameter of bolt and B is the width of the respective flat sections.

cont. E1

C3 cont

10. (New) A truss structure according to claim 8, wherein the size of the tapered edge of said flat section is determined by the following relationship:

$\ell \leqq \sqrt{2}\ t/2+10\ \sqrt{\ }\ 2+2.0\ d + B/2$, and $\ell > 3d$ (mm)

wherein ℓ is a half length of a distance between two bolt connection centers of respective flat sections of chord members oppositely positioned on the parent plate, d is the diameter of bolt and B is the width of the respective flat sections.

REMARKS

In view of the foregoing amendments of Claim 5 and deletion of Claim 4, the rejection of Claims 4 and 5 under 35 USC § 112, ¶ 2 is deemed moot.

The rejection of Claims 1-5 and 8 as being unpatentable over Hathorn in view of van Hattum and Richardson under 35 USC § 103(a) is traversed. Reconsideration is requested on grounds that the Office Action does not set forth a *prima facie* case of obviousness based upon substantial record evidence. Instead, impermissible hindsight reconstruction has been employed made possible by applicant's own teachings.

Applicant does not believe that the Hathorn patent merits any discussion in light of the Office Action's candid acknowledgment that it does not teach certain salient features claimed in this application. The only thing it discloses are conventional chord members, but nothing else.

The Richardson patent merely discloses a connection part including conical shaped or V-shaped end portions 14 and two separate parallel plates 20 formed by cutting a pair of slots 16 into the tubular member, inserting a platen edgewise into the slots and radially compressing the respective halves of the tubular member against opposite faces of the platen. The two parallel plates 20 separated by the gap 42 are used for better stress distribution between the two spaced apart plates 20. This structure will, however, substantially reduce rigidity and mechanical strength of the connection part, in that, by providing the slots 16, bridging portions connecting the two plates 20 are not formed. In addition, the two parallel plates extremely limit the application of the strut 10 to parent plates.

The van Hattum patent discloses only that the flat junction-plate 1 can function as a parent plate. The connection part of tubes 5 and 6 are, however, formed by two separate parallel plates 3, 4 as in the Richardson method. Therefore, the van Hattum patent adds nothing to the hypothetical combination.

In the present invention, the flat section of the connection part is formed by a squashed and pressed pipe member to form contiguous two layers in a loop shape which greatly increase rigidity and mechanical strength compared with the structural member formed by the Richardson method. The single piece of the flat section in the present invention allows the connection part to be applied to almost all types of parent plates. Moreover, because of the semi-spherical-shaped tubular section and the transitional slack portions 11' at both ends of the semi-circular boundary of the spherical shaped tubular section, flows of

compression force are properly transmitted to the pipe member from the connection part.

To help further illustrate the above-discussed differences, applicant provides the following additional explanation along with attached sketches.

Referring to Sketch 1 prepared by applicant, when using the ends of a compression pipe member as a pin connection, it is necessary to process the untreated pipe portion A and the plate portion B into an integral body with the following types of measures.

1. Plate Insertion Method into Pipe.

As shown at C in Sketch 1, two slitted grooves of t x ℓ are formed at the end of the pipe A. The plate B such as steel plate is inserted into the slitted grooves as shown at D, and ℓ portions at upper and lower four portions are welded.

In the compression member formed using this method, since the end portions a of the pipe A are hollow, the stress will be concentrated at four connection planes b of the pipe A and the plate B as shown in Sketch 2. Namely, compression force from the plate B is not equally distributed to the entire cross-sectional area of the pipe A. The stress on two c faces having large cross-section areas becomes extremely small in comparison with that on the four b faces having small cross-sectional areas. Consequently, transmission of stress is non-uniform. It is one of the significant drawbacks that the compression force is not directly applied to the a faces the most important pipe cutting face.

With this method, not only the stress transmission efficiency from the plate B to the pipe A and design are poor, but also the manufacturing cost is

undesirably high. The product shown in Sketch 2 has been quite broadly used up to now.

2. Pipe Squashing and Flattening Method

Mr. Shoji, the present invention, invented in 1969 a connection part integral with the pipe A as shown in Sketch 3 by squashing and flattening the end of the pipe A without using the insertion plate B as shown in Sketch 2.

In Sketch 3, the left-hand product is a flattened member having straight line a1, and the right-hand product is a flattened member having R shape a2. No difference between both products with regard to yield strength has been observed. A first application to a building in a space truss frame using the compression pipe members with such parts was for a roof truss structure of a gymnasium in Ibaraki Christian University in Hitachi City in 1980. This structure is still in use and photos marked "A" thereof are also enclosed.

The compression pipe member manufacture according to Mr. Shoji's method is, however, much better than the earlier method of plate insertion (Sketch 1) with regard to cost and stress transmission efficiency. However, Mr. Shoji noted that the compression pipe member still had the following four drawbacks:

1) Unusual angled points a3 (Sketch 3) appear on the end portion at two locations to which stress is concentrated, which reduces mechanical strength of the member,

2) The pipe cross-section in the section L is not completely round but elliptical,

3) When the ratio of diameter d and thickness t of the pipe d/t increases, the elliptical section L is elongated, in that L ≒ 3d ~ 5d, and

4) When the elliptical section is increased, local buckling can be caused at the section.

The above-described state of the art was summarized at page 2, lines 6-22 of the original Specification.

3. Pipe Squashing and Flattening Method with V-Shaped Transition Region

The structure shown in Sketch 4 was also invented by Mr. Shoji after 1980 to achieve a structure which smoothly transmits the compression stress from the plate B to the pipe A. Although the undesirable angles points a3 were eliminated, the length L' of elliptical section was not substantially reduced.

The present inventor has continued to search for a structure that permits smooth stress transmission from the plate B to the pipe A. That structure is claimed in the present application and is shown in attached Sketch 5 which will be used for further explanation. The connection part of this structure includes two transitional slacks, extrusion or runout portions a4 at right and left ends of the semi-circular boundary which perform an important function as described at page 9, lines 11-19 of the original Specification.

Among the flows of the compression force input from the plate portion B, the flow P1 at the center portion is directly input via the curved face a5 of the transitional portion in the pipe A to the main body of pipe A. The flow of compression force P2 at the right and left extruded portion from the pipe diameter is input via the portions a4 to the main body of pipe A. The mechanism

in which the flow of compression force P2 is input to the main body of pipe A via the portion a4 is relatively complex.

As a result of experiments, it has been discovered that P2 forms a resultant force R running along the outer periphery of the portion a4 and is input at point O on the pipe A in a diagonal direction. Each resultant force R input at points O from the right and left extrusion portions a4 is divided into two component forces Rx, Ry, The component force Ry is input into the side face of the pipe A as a compression force, and the component force Rx is input at the both sides of the pipe as shearing forces. This causes no problems because the same is input to the pipe A together with the flow of compression force P1 input in the axial direction.

The two component forces Ry are input at points O of the pipe A in a radial direction thereof as compression force which is significant. As the result of experiments, it was observed that the pipe A depresses in the component force Ry direction at points O and it is also found out that the yield strength of the depression deformation corresponds to the compression yield strength of the pipe A as it is. The yield force of the compression deformation is extremely high and corresponds to about more than 80% of the compression yield strength in axial direction of the untreated pipe.

The above discovery allows the specific connection part of the pipe member according to the present invention to be used for general purpose compression pipes and is applicable to full-scale truss members and structural members. All of the connection parts for pipes having small diameter to large diameter can be formed in similar forms with a limited process number and low coast as well as

with good design. As a result, the corresponding Japanese patent application was deemed patentable and was registered on October 1, 1999 as Japanese Patent No. 2,987,343.

As shown in attached Table 1 which shows 28 types of pipe connection parts according to the present invention available from RNA Research Laboratory run by Mr. Shoji, wherein, for example, 406.4 x 16.0 at right bottom means a pipe outer diameter of 406.4 mm and a pipe thickness of 16.0 mm, the pipe connection part structure according to the present invention can be applied to compression pipe members for almost all full-scale structural members covering all pipes from small diameter to large diameter. The present invention extremely facilitates processing of pipes with extremely low cost.

When, for example, the connection part structure of the present invention is applied to the pipe members for a space truss structure, the cost will be reduced to 1/10 - 1/15 in comparison with a conventional truss structure using conventional ball joints. Therefore, the cost of the frame structure using the present truss structure can be reduced by half compared with a conventional heavyweight iron frame structure with a 1.5-times earthquake-proof structure.

The "RNA truss system" utilizing the present invention has been evaluated and registered in New technology Information Providing System (NTIS) of Ministry of Land, Infrastructure and Transport of Japan as Registration No. KT 00008, which permits registration of new technology applicable to public facilities. The "RNA truss system" reduces the weight of steel members for an iron-framed building by one-third over conventional methods.

Accordingly, reconsideration and favorable action are earnestly solicited.

If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket #1892/47565).

Respectfully submitted,

December 26, 2002

James F. McKeown
Registration No. 25,406

CROWELL & MORING, LLP
P.O. Box 14300
Washington, DC 20044-4300
Telephone No.: (202) 624-2500
Facsimile No.: (202) 628-8844

JFM/acd
037227.47565US

VERSION WITH MARKINGS TO SHOW CHANGES

IN THE CLAIMS:

1. (Twice amended) A truss structure comprising an upper chord member, a lower chord member and a diagonal chord member connected to a parent plate via a connection part formed on an end of each of said chord members, wherein

said upper chord member, said lower chord member and said diagonal chord member each comprise a pipe member;

said connection part comprises a tubular section, and a flat section formed integral and continuously with said tubular section which are formed of said pipe member having a same diameter by a constrained pattern shaping press; and

said connection part is connected to said parent plate via a bolt opening formed in said flat section and is formed of the pipe member by a constrained pattern shaping press to comprise a tubular section to have a curved surface, and extending from and integral with the pipe member, and a flat section being from a flattened pipe member as a single piece having width determined by the diameter of the pipe member, and extending from and integral with the tubular section, the tubular section defining a semi-circular boundary with the flat section and the flat section including respective transitional slack portions at both ends of the semi-circular boundary of the tubular section.

2. (Twice amended) A truss structure comprising an upper chord member, a lower chord member and a diagonal chord member connected to a

parent plate via a connection part formed on an end of each of said chord members, wherein

said upper chord member, said lower chord member and said diagonal chord member each comprise a pipe member;

said connection part comprises a pipe tubular section which is formed by a cylindrical drawing process of said pipe member having a same diameter, and a flat section formed integral with said pipe tubular section by a flat press; and

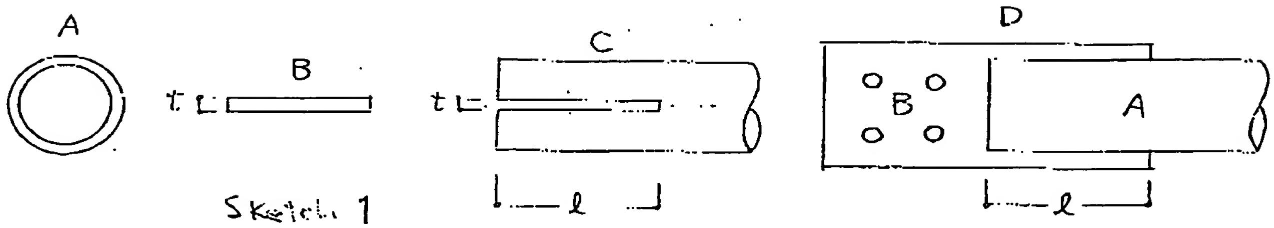
said connection part is connected to said parent plate via a bolt opening formed in said flat section <u>and comprises a pipe tubular section being formed of the pipe member by a cylindrical drawing press to have a curved surface, and extending from and integral with the pipe member, and a flat section being formed from a flattened pipe member through a flat press into a single piece having width determined by the diameter of the pipe member, and extending from and integral with the pipe tubular section, the pipe tubular section defining a semi-circular boundary with the flat section and the flat section including respective transitional slack portions at both ends of the semi-circular boundary of the pipe tubular section</u>.

3. (Twice amended) A truss structure according to claim 1, wherein [said connection part further comprises] said parent plate [and] <u>includes</u> a rib erected crosswise thereon, and [wherein] an edge of said flat section is tapered to allow for each flat section of each chord member to be positioned in close proximity.

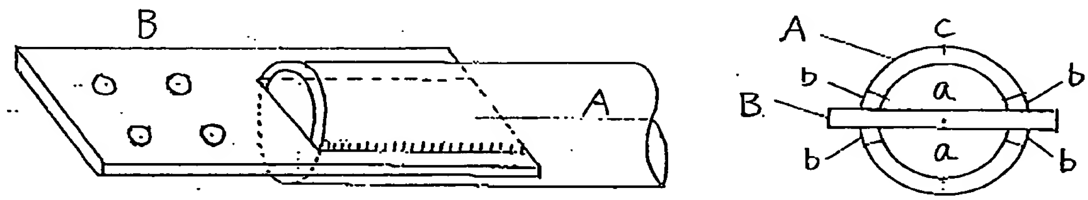
5. (Twice amended) A truss structural member for use in a truss construction including [such as] an upper chord member, a lower chord member and a diagonal chord member, each having a connection part formed on an end thereof, wherein said connection part comprises:

a tubular section which is formed by a cylindrical constrained shaping of a pipe, and

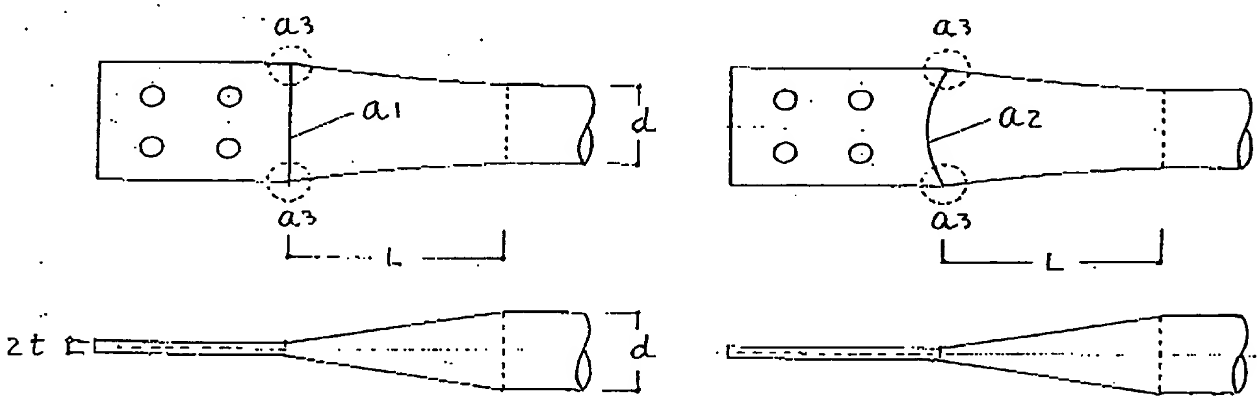
a flat section which is formed integral with said tubular section by a flat compression press, and wherein a bolt opening is formed in said flat section, wherein said connection part comprises a tubular section being formed of a pipe member of the respective chord members by a cylindrical constrained shaping having a curved surface, and extending from and integral with the pipe member, and a flat section being formed from a flattened pipe member through a flat compression press into a single piece having width determined by the diameter of the pipe member, and extending from and integral with the tubular section, the tubular section defining a semi-circular boundary with the flat section and the flat section including respective transitional slack portions at both ends of the semi-circular boundary of the tubular section, and a bolt opening is formed in said flat section.



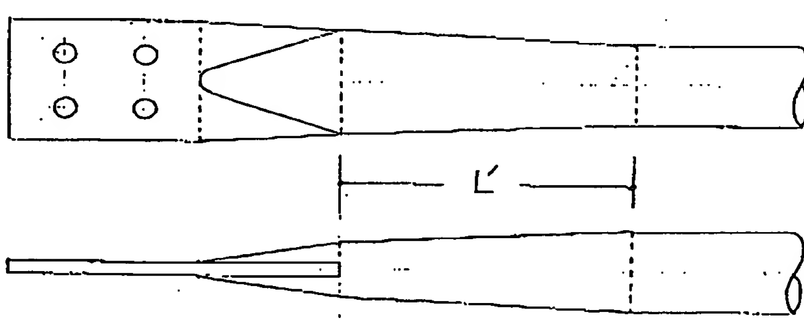
Sketch 1



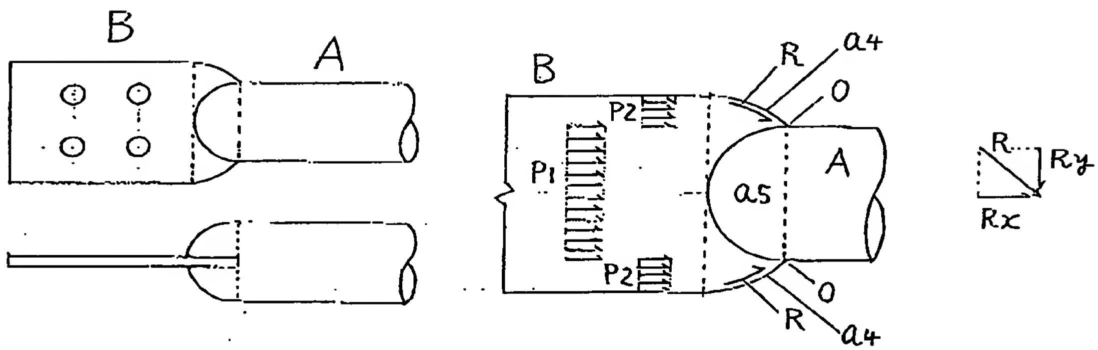
Sketch 2



Sketch 3



Sketch 4



Sketch 5

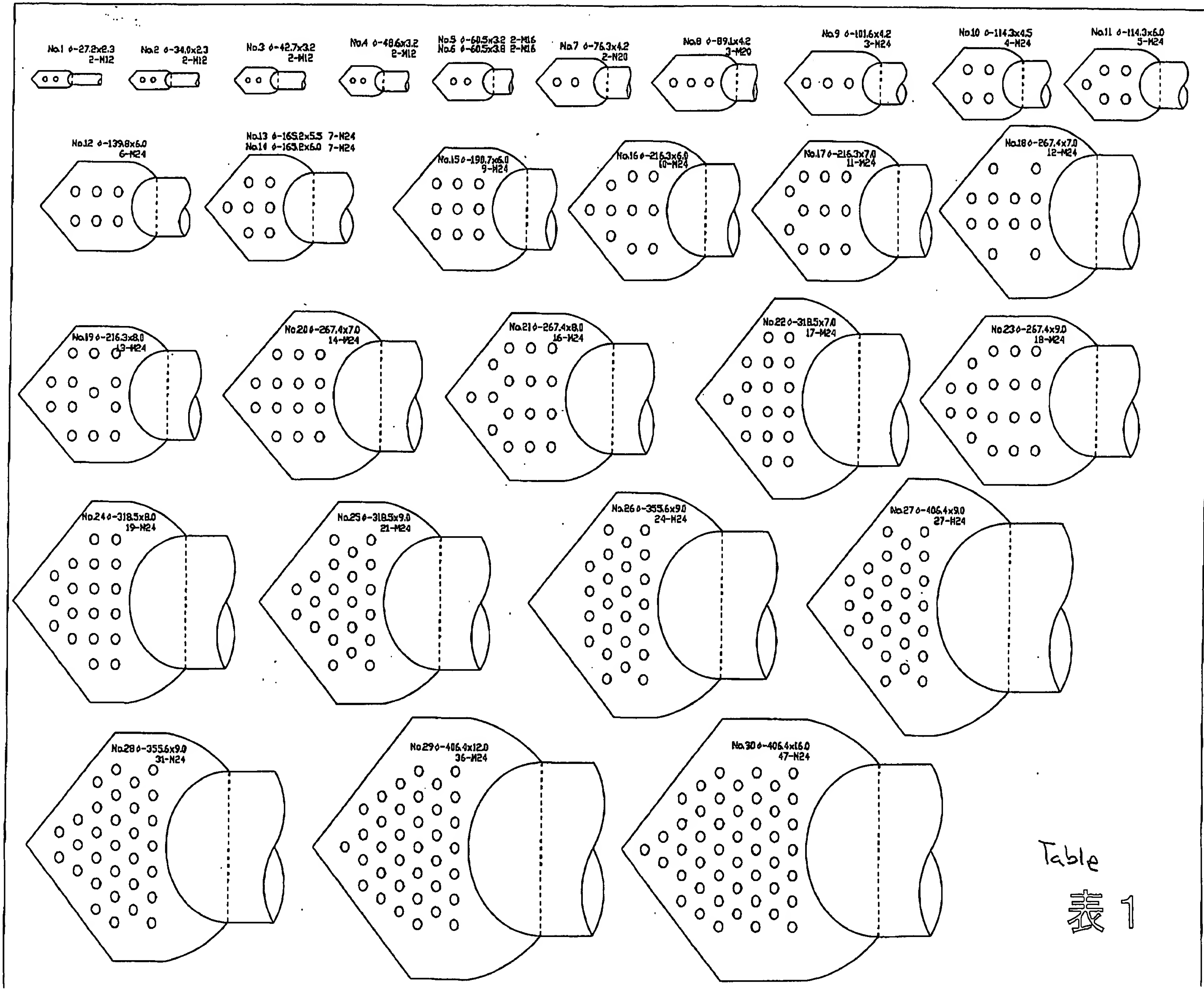
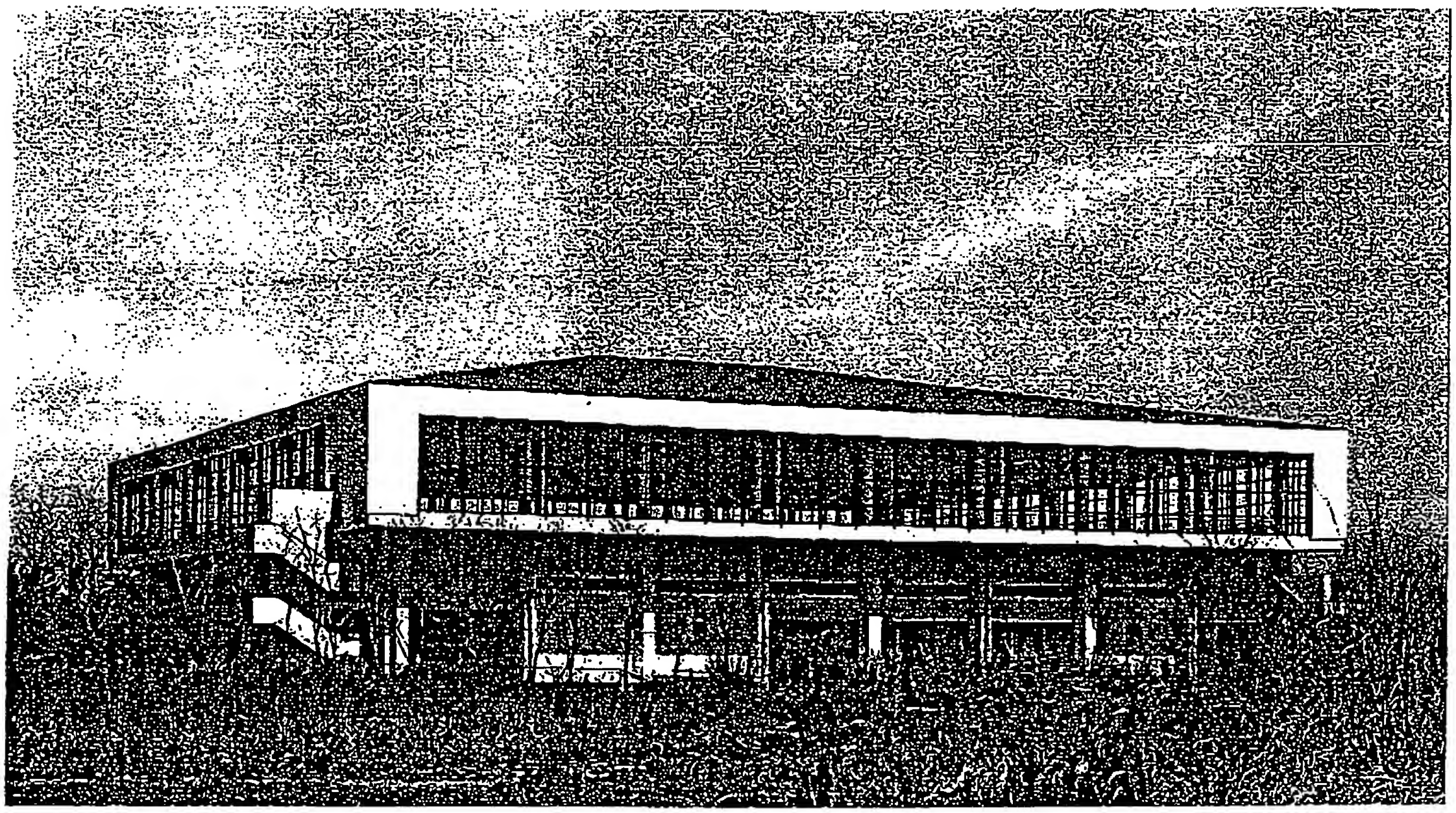
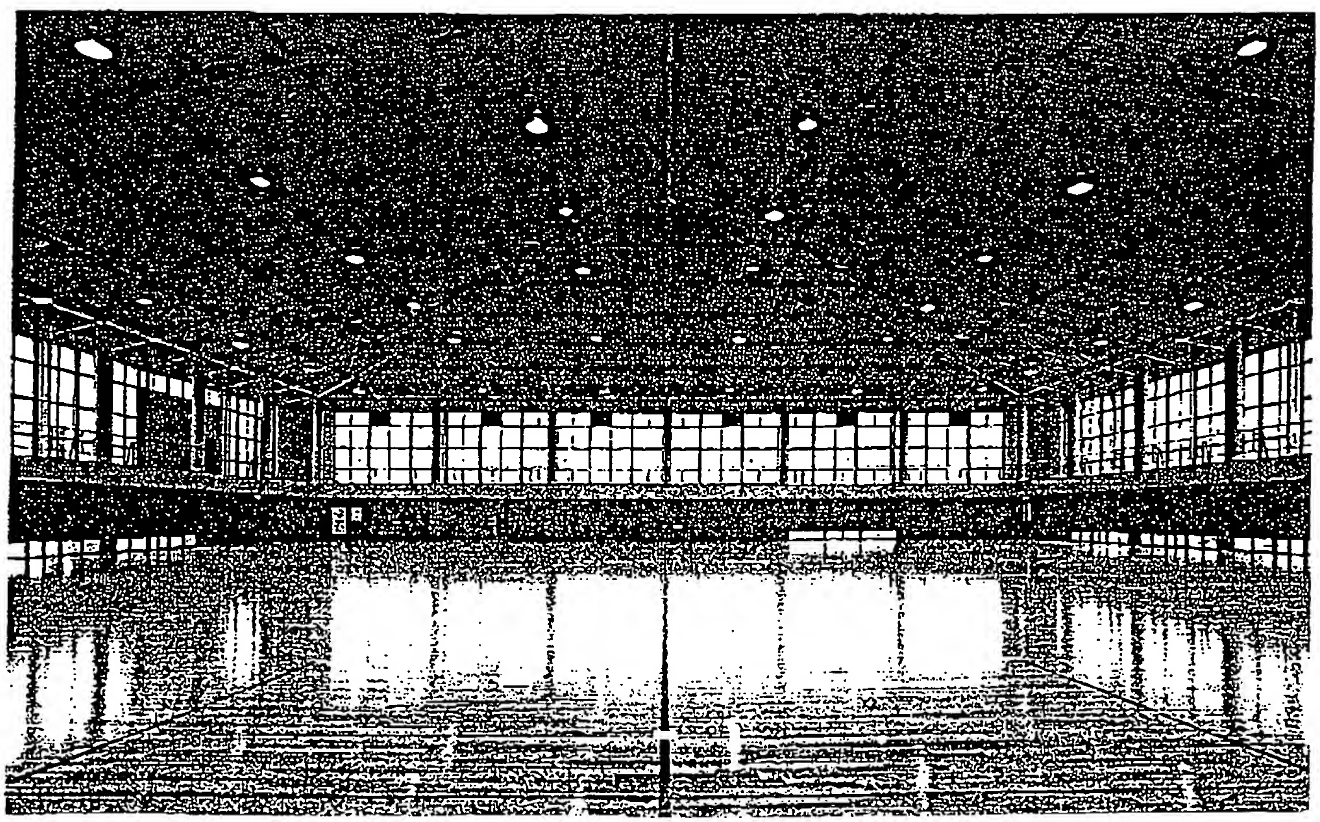

No.1 φ-27.2x2.3 2-M12
No.2 φ-34.0x2.3 2-M12
No.3 φ-42.7x3.2 2-M12
No.4 φ-48.6x3.2 2-M12
No.5 φ-60.5x3.2 2-M16
No.6 φ-60.5x3.8 2-M16
No.7 φ-76.3x4.2 2-M20
No.8 φ-89.1x4.2 3-M20
No.9 φ-101.6x4.2 3-M24
No.10 φ-114.3x4.5 4-M24
No.11 φ-114.3x6.0 5-M24
No.12 φ-139.8x6.0 6-M24
No.13 φ-165.2x5.5 7-M24
No.14 φ-165.2x6.0 7-M24
No.15 φ-190.7x6.0 9-M24
No.16 φ-216.3x6.0 10-M24
No.17 φ-216.3x7.0 11-M24
No.18 φ-267.4x7.0 12-M24
No.19 φ-216.3x8.0 13-M24
No.20 φ-267.4x7.0 14-M24
No.21 φ-267.4x8.0 16-M24
No.22 φ-318.5x7.0 17-M24
No.23 φ-267.4x9.0 18-M24
No.24 φ-318.5x8.0 19-M24
No.25 φ-318.5x9.0 21-M24
No.26 φ-355.6x9.0 24-M24
No.27 φ-406.4x9.0 27-M24
No.28 φ-355.6x9.0 31-N24
No.29 φ-406.4x12.0 36-M24
No.30 φ-406.4x16.0 47-M24

Table
表1

パイプ半つぶしと十字孔の組合わせで出来た金属部の作品です A



(1980)　茨城キリスト教短大の体育館(日立市大みか町)
寄棟タイプ (スパン36×44 m)



A TRUSS STRUCTURE, MEMBERS THEREOF, AND A METHOD OF MANUFACTURE THEREFOR

BACKGROUND OF THE INVENTION

The present invention relates to a truss structure for use in a roofing and the like of a building.

As a space truss structure which can shorten the term for completion of work by facilitating the connection of its chord members, a conventional truss structure is disclosed in JPA Laid-Open No. 60-89744 [, in which a]. A connection member is provided on one surface of which a connection tube for connecting chord members is erected, and on the other surface of which a rib for connecting diagonal chord members is mounted, whereby chord members each having a connecting part on the end thereof are connected thereto via washers which may be in any numbers. Further, JPA Laid-Open No. 5-311765 discloses a flat metal square column pipe member having a concave cross-section fitting member on both ends thereof formed by press or roll working, and wherein [said] the concave cross-section fitting part is provided with a long narrow opening for fitting which is pierced therethrough. Still further, a double pipe type truss beam which integrates an upper chord member and a lower chord member formed of a pipe, and a web member is disclosed in JPA Laid-Open No. 7-180217. Still [more] further, JPA Laid-Open No. 61-100704 discloses a connection structure for a truss joint which is comprised of joining diagonal pipe members via a cross gausset plate to an M-shaped, H-shaped chord members or to a vertical pipe member, wherein a backup member outside the truss plane of the gausset plate

is omitted such that the bore of the pipe between a flange and a web of the chord member is effectively utilized.

As mentioned above, various efforts have been made in order to facilitate the connection of the chord members and shorten the term for completion of work. Also, it is known to flatten the connection edge of the chord member by compression pressing to this effect. In this conventional structure, however, existence of a free plastic deformation part, which is elliptic and extends between the flat surface provided by compression pressing and the complete round section of a parent pipe member cannot be avoided. This long and narrow free plastic deformation part adjoining the connection end structure flattened by compression according to the conventional method is not only unnecessary but also disadvantageous in the truss structure because the size of the parent plate for connecting the chord member using a bolt thereto becomes inevitably large. Provision of such a large sized parent plate has been a cause to increase the size of its joint structure, thereby decreasing its rigidity, and increasing the cost of manufacture.

SUMMARY OF THE INVENTION

An object of the present invention is to provide for a truss structure which can improve its rigidity by reducing the size of its joint structure, and [improve] <u>lower</u> the cost of manufacture by reducing the size of its parent member plate.

Another object of the invention is to provide for structural members suitable for use in constructing this truss structure, and a method of manufacture thereof.

One of the features of the present invention resides in [that] an edge portion of a pipe [is] <u>being</u> forcibly pressed between an upper die and a lower die, each having a same cylindrical surface of constraint. By use of such dies, it becomes possible to directly form a flat surface section on the edge of a pipe member while securing a complete round portion thereof serving as a [complete round] parent member. Therefore, the long free plastic deformation part which is inevitably formed using the conventional dies having a flat surface portion for forming a <u>conventional</u> flat structure [according to the conventional art] can be eliminated, and a connection edge having a flat surface which is directly connected to the complete round parent member can be realized according to the invention. The present invention, as stated above, is characterized by the forced constrained pattern pressing of the edge portion of the pipe using the upper and the lower dies having a cylindrical semi-surface of constraint. However, it is not limited thereto, and a modification of which for providing a polygonal or a short elliptical structures instead of the cylindrical [one should be construed] <u>is</u> within the scope of the invention. Essentially, in forming the flat section, it is intended to form a constrained tubular portion between the flat section and the complete round parent member by a constrained pattern forming press, and the shape of this constrained tubular portion may be the same as the pipe as the complete round parent material or any shape required in its design.

More specifically, the truss structure, structural members therefor and the method of manufacture thereof as will be described below are provided according to the invention.

The present invention provides for the truss structure for connecting an upper chord member, lower chord member and diagonal chord member to its parent plate via respective connection parts of each member provided on both ends thereof, wherein the upper chord member, the lower chord member and the diagonal chord member used is a pipe member, and wherein the connection part of the pipe member is comprised of a tubular portion forcibly shaped into the same diameter and the flat surface portion formed integral with the tubular portion by compression pressing, further wherein the connection part is connected to the parent plate via a bolt opening provided in the flat surface portion.

Preferably, the connection part member includes the parent plate and a rib member erected cross-wise thereon, and each edge portion of each flat surface part is tapered and arranged in juxtaposition.

[In the] <u>The</u> truss structure according to the invention [having] <u>has</u> the upper chord member, the lower chord member and the diagonal chord member, each having the connection part on the both ends thereof for connecting to the parent plate therethrough[, wherein the]<u>. The</u> upper, the lower and the diagonal chord members use a pipe member, and the connection part has a flat surface portion formed by the compression pressing, with the edge portion of the flat surface portion being tapered[, and wherein assuming]<u>. Assuming</u> a distance (2 x

l) between connection center positions of two flat portions of juxtaposed two chord members to be Ul" when divided by 2, and a diameter of a bolt opening provided in the flat surface portion to be "d", [there holds a] <u>the following</u> relationship between "1" and “d” [as follows] <u>exists</u>.

$$1 \leqq \sqrt{2}\ t/2+10\sqrt{2}\ +2.0\ d+B/2, \text{ and } 1>3d \text{ (in mm).}$$

According to one aspect of the invention, the truss structural members [are provided which] include the upper chord, the lower chord and the diagonal chord members, each having a connection part on the both ends thereof[, wherein said]<u>. The</u> connection part is comprised of the tubular portion forcibly formed into the constrained pattern with a constrained restriction, and the flat surface portion formed integral with the tubular portion by flat pressing, and [wherein] the bolt opening is provided in the flat surface portion.

According to another aspect of the invention, the die is provided for forming the connection part on the edge portion of the truss structural members such as the upper chord, the lower chord and the diagonal chord members, which are tubular, wherein the die [IS] <u>is</u> comprised of an upper press die and a lower press die[, each]<u>. Each</u> die [having] <u>has</u> a half tubular curved surface open to the outside and placed oppositely to provide for a constraint groove in combination whereby [to be able to form] a constrained pattern <u>is able to be formed</u>.

According to still another aspect of the invention, the method for manufacturing the truss structural members such as the upper, the lower and the diagonal chord members which are provided with respective connection parts

on both ends thereof [is provided, wherein the same] comprises the steps of: placing a pipe between the upper and the lower press dies, each having the half tubular curved surface which is open to the external and positioned oppositely so as to provide for in combination one constrained shape; and [forming] simultaneously <u>forming</u> the flat surface portion connected integral with the tubular portion by pressing.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

Fig. 1 is a schematic plan view of a truss structure embodying the invention;

Fig. 2 is a cross-sectional view of Fig. 1;

Fig. 3 is a plan view of a joint according to one embodiment of the invention;

Fig. 4 is a cross-sectional side view of Fig. 3;

Fig. 5 is a perspective view [indicating] <u>illustrating how</u> a method of manufacture according to the invention <u>is implemented</u>;

Figs. 6 (a)[,] <u>and</u> (b) show two different embodiments of the invention;

Figs. 7(a)[,] <u>and</u> (b) show still other embodiments of the invention; and

Figs. 8 (a)[,] <u>and</u> (b) show examples of joint structures using the embodiments of Figs. 6 (a)[,] <u>and</u> (b).

[PREFERRED EMBODIMENTS] <u>DETAILED DESCRIPTION OF THE DRAWINGS</u>

With reference to Figs. 1 and 2, a plan view and a cross-section of a truss structure according to the invention are shown. In these drawings, numeral 1 depicts a lower chord member, 2 depicts an upper chord member, 3 depicts a diagonal chord member, and 4 depicts a cross plate, respectively. This truss structure [which] is formed by lower chord member 1, upper chord member 2 and diagonal chord member <u>and</u> has a rectangular cross-section extending in a span direction and a column direction. The lower chord member 1, the upper chord member 2 and the diagonal chord member 3 are jointed to the cross plate 4 with bolts for assembly. The cross plate 4 is formed by welding a plate for the chord member and a plate for the diagonal chord member [in] crosswise.

Now, with reference to Figs. 3 and 4, a connection part lQ of the chord member is comprised of a flat surface section 11 and a constrained complete round pipe section 12. The constrained complete round pipe section 12 as will be described later is a constrained complete round portion formed by compression between the upper and the lower press dies, and [having] <u>has</u> a structure directly connected to the flat surface portion 11. However, because there naturally exists a transitional deformation portion from the complete round portion to the flat surface portion, it should be understood that a curved surface portion 13 having a small radius of curvature must be formed therebetween. This curved surface is also constrain-formed and [has] <u>is</u> a semi-circle. The leading edge of the flat surface portion is formed into a tapered shape 14. A plurality of bolt holes 17 are

formed along a line connecting between the tapered leading edge portion and the center of the constrained complete round pipe portion 12 (two bolt holes are provided in the case of Fig. 3). The connection part 10 of the chord member has the flat surface portion 11 formed by the compression pressing as will be described more [in detail later] fully below, and bolt holes 17 are formed into this flat surface portion 11, [and the]. The leading edge of the flat surface portion 11 is tapered into a pointed shape 14. This connection part 10 is firmly connected with bolts 18 to parent plates 15 [and], 16 which are assembled cross-wisely by welding. The method of manufacture thereof will be described with reference to Fig. 5.

The die is comprised of the upper die press 21 and the lower die press 22, and in each die press, there are formed a flat surface press section 23, a semi-circular cylindrical surface press section 24 and a curved surface press section 25. A pipe chord member 1, 2, 3 is placed in the semi-circular cylindrical surface press section 24 between the upper and the lower die press 21, 22, and forcibly pressed. By [provision of such arrangements] so providing, a connection part 10 having the structure as shown in [Fig. 5] (c) of Fig. 5 can be obtained wherein the constrained complete round pipe portion 12 and the flat surface portion are directly connected via the curved surface portion 13. The edge portion of the connection part 10 may be prefabricated then pressed, or may be fabricated after presswork.

With reference to (c) of Fig. 5 [(c)], there is formed a transitional slack portion 11" on the edge portion of the pipe 12 flattening from the complete round

constrained tube. This flattening slack portion ll' having axial length "a" which extends from the pipe 12 to the flat surface part 11 has an important function to transmit a stress from the section 11 to the section 12. The conventional connection part of an elliptical shape formed using the conventional flat press does not have this portion ["a"] 11' according to the invention.

An advantage realized by provision of the tapered leading edge at the connection part 10 will be described in the following Figs. 6 (a) and (b) [show] showing two examples of the invention, in which (a) indicates one without tapering, and (b) indicates one with a tapered leading edge. In the case of (b), an angle of its leading edge tapering corresponds to an angle of a parent plate 16 which is mounted crosswise. Here, let's assume that a diameter of a bolt is "d", and a distance between the center of the diameter of a forefront bolt and the center of joint of the crosswise parent plate is "L" in the case of (a), and "l" in the case of (b). Namely, "L" or "l" represents a half-length of a distance between counterposed joints. Further, symbol "B" & "t" [depict] represent, a width of a flattened pipe or chord member plate[,] and a thickness of the parent plate for use of the diagonal chord members, respectively.

Figs. 7 (a) and (b) show other embodiments of tapered flat plate sections of the invention. Fig. 7(a) is an example having rounded corners, and Fig. 7 (b) is an example which is tapered into a sword edge.

Examples of truss structures assembled using the embodiments of Figs. 7 (a) and (b) are shown in Fig. 8. Numeral 150 depicts a plate for diagonal chord members. As clearly understood from the drawing, by provision of a tapered

sword edge to the flattened plate section of the pipe, a distance from the center of joint to the center of the bolt can be shortened substantially. It is easily understood as well that the sizes of parent plates 15 [and], 16 can be reduced. It should be noted here that by adoption of "l" which is shorter than "L", the mechanical stability and endurance of the joint can be increased substantially. Further, the cost of manufacture thereof can be reduced. In [the case of] the embodiment of Fig. 6 (b), a relationship between "l" and "d" is defined to be $l/d \fallingdotseq 4$[,]; however, it is not limited thereto, and the following equations may be adopted depending on the types of bolts to be used.

In the case of Fig. 6 (b):

$$l \leqq \sqrt{2}\, t/2 + 10\sqrt{2} + 2.5d \text{ (mm)} \qquad \text{(eq. 1)}$$

In the case of Figs. 7(a) and (b):

$$l \leqq \sqrt{2}\, t/2 + 10\sqrt{2} + 2.0d + B/2 \text{ (mm)} \qquad \text{(eq. 2) and}$$

$$l > 3d \qquad \text{(eq. 3).}$$

In the case of Fig. 6 (a):

$$\sqrt{}\ 2t/2 + 10\sqrt{}\ 2 + 2.5d \text{ (mm)} < L \leqq \sqrt{}\ 2t/2 + 10\sqrt{}\ 2 + 2.5d + B/2 \text{ (mm)}$$

(eq. 4).

With the diameter of the bolt assumed to be "d", and the leading edge to be tapered, any length of "l" can be determined according to the above-mentioned equations. Therefore, the distance between two separate joints can be shortened substantially thereby improving the rigidity of the joints compared to those of

the embodiment of Fig. 6 (a). Some examples according to the invention are shown in Table 1.

TABLE 1: EXAMPLES OF QUANTITIES

(B=63.4, in mm.)

when t=6:

d	Fig. 6(a)	Figs. 7(a) & (b)	Fig. 6(a)
12	48.4	74.1	80.1
16	58.4	82.1	90.1
20	68.4	90.1	100.1
22	73.4	94.1	105.1
24	78.4	98.1	110.1

when t=9:

d	Fig. 6(a)	Figs. 7(a) & (b)	Fig. 6(a)
12	50.5	76.2	82.2
16	60.5	84.2	92.2
20	70.5	92.2	102.2
22	75.5	96.2	107.2
24	80.5	100.2	112.2

Further, even in [the cases of] <u>the</u> examples of Fig. 6 (a) of the invention, because the plastic deformation portions inevitably present in the conventional products are eliminated, inter-distance between the joints can be shortened, thereby increasing the rigidity of the joints accordingly.

As described heretofore, because the pipe member serving as the chord member is provided with the constrained curved surface section and flattened tube section on both ends thereof which are formed by the constrained pattern shaping pressing in order to facilitate the connection and assembly thereof, the

design limitation involved in the prior art [that] resulting the size of the parent plates [becomes] becoming inevitably large due to the existence of the free plastic deformation portion therein can be eliminated. Therefore, the size of the parent plates can be decreased substantially[, thereby increasing] and the rigidity of the joints can be increased.

Further, by provision of the tapered leading edge to the flattened connection part of the chord members, the inter-joint distance can be reduced substantially, thereby increasing the rigidity of the joint.

The foregoing disclosure has been set forth merely to illustrate the invention and is not intended to be limiting. Since modifications of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and equivalents thereof.